Climate Science, Climate Policy and Montana

Tom Fiddaman
5/20/2010
Rates of change in natural and anthropogenic radiative forcing over the past 20,000 years
Fortunat Joos and Renato Spahni
PNAS, vol. 105 no. 5
Atmospheric Greenhouse Gases (GHGs)

GHG Emissions

GHGs in Atmosphere

Net Removal

 Courtesy of John Sterman, MIT
CO2 Emissions & Concentration

Emissions

Atmospheric Concentration
**Millennial Temperature Reconstructions**

Fig. 1. Proxy based temperature reconstructions from AD1000 to present for various regions on hemispheric to global scales: see text for details. With mean of 1900 to 1960 removed, 21-year running means. NH mean instrumental temperatures are shown for the period AD1866 to 1995.

Millennial temperature reconstruction intercomparison and evaluation
Atmospheric Temperature

Light from the sun

Heat in Earth System

Infrared radiation to space

Courtesy of John Sterman, MIT
Global Surface Temperature

F2
better color
show projections
get rid of short term

Frd, 5/20/2010
Montana Temperatures

Glaciers
Boulder Glacier, Glacier NP

1910

2007

Northern Hemisphere Extent Anomalies Mar 2010

1979-2000 mean = 15.7 million sq km

slope = -2.6(+/-0.7) % per decade

National Snow & Ice Data Center, retrieved 4/7/2010 from http://nsidc.org/data/seaice_index/
Disappearing Arctic Sea Ice

Sept 1979

Sept 2007

Less moisture—more fires. Between 1970 and 2003, spring and summer moisture availability declined in many forests in the western United States (left). During the same time span, most wildfires exceeding 1000 ha in burned area occurred in these regions of reduced moisture availability (right). [Data from (4)]
Slide 14

F4  Acidification
    Fid, 5/20/2010

F5  precipitation
    Fid, 5/20/2010
The Future
IPCC AR4 Temperature Projections

Multi-model averages and assessed ranges for surface warming

Global surface warming (°C)

Year

1900 2000 2100

B1 A1T B2 A1B A2 A1FI
Sea Level Rise Projections

Fig. 6. Projection of sea-level rise from 1990 to 2100, based on IPCC temperature projections for three different emission scenarios (labeled on right, see Projections of Future Sea Level for explanation of uncertainty ranges). The sea-level range projected in the IPCC AR4 (2) for these scenarios is shown for comparison in the bars on the bottom right. Also shown is the observations-based annual global sea-level data (18) (red) including artificial reservoir correction (22).

Vermeer & Rahmstorf (2009) Global sea level linked to global temperature PNAS vol. 106 no. 51 Dec 22 2009
Climate Weirding

Disappearing Climates with High Emissions (SRES A2)

Fig. 3. ... pool of potential analogs is restricted to gridpoints within 500km of each target gridpoint
John W. Williams, Stephen T. Jackson, and John E. Kutzbach. Projected distributions of novel and disappearing climates by 2100 AD. PNAS, vol. 104 no. 14
Manage the Unavoidable: Adapt

2050
“BAU” warming
Ave: 2.6°C
Max: 6.3°C

Avoid the Unmanageable: Mitigate Emissions

2100
“BAU” warming
Ave: 6.3°C
Max: >20°C

Temp. Difference (°C)
- 0 - 1
- 1 - 2
- 2 - 3
- 3 - 5
- 5 - 20
- 20-28
Difficulty assessing proposals

“...delegates [in Bonn] complained that their heads were spinning as they were trying to understand the science and assumptions underlying the increasing number of proposals tabled for Annex I countries’ emission reduction ranges.”

“They all seem to use different base years and assumptions...: how can we make any sense of them?”

http://www.iisd.ca/vol12/enb12403e.html
## Current Confirmed Proposals

<table>
<thead>
<tr>
<th>Country</th>
<th>2020</th>
<th>2050</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>5% below 2000</td>
<td>60% below 2000</td>
<td>20% renewable energy by 2020</td>
</tr>
<tr>
<td>Brazil</td>
<td>36% below business-as-usual</td>
<td></td>
<td>Amazon deforestation 70% below 2009 by 2017</td>
</tr>
<tr>
<td>China</td>
<td>Carbon intensity 45% below 2005</td>
<td>Increase forest coverage 40M Ha by 2020</td>
<td></td>
</tr>
<tr>
<td>EU</td>
<td>20% below 1990</td>
<td>80% below 1990</td>
<td></td>
</tr>
<tr>
<td>Russia</td>
<td>20% below 1990</td>
<td>50% below 1990</td>
<td></td>
</tr>
<tr>
<td>US</td>
<td>17% below 2005</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

and so on ...

“Currently, in the UNFCCC negotiation process, the concrete environmental consequences of the various positions are not clear to all of us.

There is a dangerous void of understanding of the short and long term impacts of the espoused …unwillingness to act on behalf of the Parties.”

– Christiana Figueres, UNFCCC negotiator for Costa Rica
**Carbon Dioxide (CO2) Fossil Fuel Emissions**

<table>
<thead>
<tr>
<th>Year</th>
<th>US</th>
<th>EU</th>
<th>China</th>
<th>India</th>
<th>Other Developed</th>
<th>Other Developing</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>150</td>
<td>120</td>
<td>90</td>
<td>60</td>
<td>30</td>
<td>0</td>
</tr>
<tr>
<td>2100</td>
<td>200</td>
<td>200</td>
<td>200</td>
<td>200</td>
<td>200</td>
<td>200</td>
</tr>
</tbody>
</table>

**Global Temperature Change**

- **BAU**: Stabilize at 5°F
- **Stabilize**: Temperature change from preindustrial (Deterministic) - Stabilize
- **REF**: Temperature change from preindustrial (Deterministic) - REF

**Goal for Temperature**

- BAU: 9°F
- Stabilize: 5°F
Emissions - Cut 50%

Temperature

Temperature change from preindustrial["2°C"] : -50 percent
Temperature change from preindustrial[Deterministic] : -50 percent
Temperature change from preindustrial["4.5°C"] : -50 percent
Goal for Temperature : -50 percent

3°F
The world wasn’t ready

- Negotiators didn’t have the mandate to achieve a meaningful agreement

Result: as of recently, +7 degrees F in 2100
Model Futures for Montana
Average of GISS ER, CCSM, ECHAM5 ensembles from climexp.knmi.nl, lat 45.7 lon -110.9

Precipitation

- 3-Model Avg
- BOZEMAN MONTANA ST U
- WEST YELLOWSTONE
- Precip

Temperature (°C)

- 1900 1920 1940 1960 1980 2000 2020 2040 2060 2080 2100

Precipitation (mm/day)

- 0 0.2 0.4 0.6 0.8 1 1.2 1.4 1.6 1.8 2

Bozeman

West Yellowstone
F6  how do we know it's not uhi
  Fid, 5/20/2010

F7  fahrenheit
  Fid, 5/20/2010
Energy Emissions - WCI Partners, Observers & Others

Sources:
EPA - State CO2 Emissions from fossil fuel combustion, 1990-2005
Environment Canada - National Inventory Report 1990-2005: Greenhouse Gas Sources and Sinks in Canada
Emissions per GDP

Sources:
EPA - State CO2 Emissions from fossil fuel combustion, 1990-2005
US GDP – EIA SEDS; Canada GDP – Statistics Canada, converted to $US at market exchange rates
Current Technologies Can Reduce Emissions

Socolow, Princeton
McKinsey: Initial Emissions Reductions Save Money

Triggering the Good Tipping Points

• **Regional Government**
  - Imitation of successful policies
  - Complementary infrastructure

• **Corporate**
  - Economies of scale, learning curves
  - Networks, thought leadership

• **Personal**
  - Habits
  - Word of mouth, knowledge diffusion
  - Vision – what seems possible
Many policies are “no regrets”
Thanks!

Slides will be posted at http://blog.metasd.com
This figure was produced by Leland McInnes using python and matplotlib and is licensed under the GFDL. All data is from publicly available sources.

Data Sources
(red) EPICA Dome C temperature data: http://doi.pangaea.de/10.1594/PANGAEA.683655
(dark blue) Vostok CO2 data: http://doi.pangaea.de/10.1594/PANGAEA.55501
(steel blue) EPICA Dome C temperature data, 423-391 kybp: http://doi.pangaea.de/10.1594/PANGAEA.472482
(pale blue) EPICA Dome C CO2 data, 650-413 kybp: http://doi.pangaea.de/10.1594/PANGAEA.472481
(cyan) EPICA Dome C CO2 data, 800-650 kybp: http://doi.pangaea.de/10.1594/PANGAEA.710901
WCI Partner Emissions, 2005

Sources:
EPA - State CO2 Emissions from fossil fuel combustion, 1990-2005
Environment Canada - National Inventory Report 1990-2005: Greenhouse Gas Sources and Sinks in Canada
US Energy Infrastructure

Source:
EIA State Energy Profiles, 2009; http://tonto.eia.doe.gov/state/
Emissions per Capita

Sources:
EPA - State CO2 Emissions from fossil fuel combustion, 1990-2005
Environment Canada - National Inventory Report 1990-2005: Greenhouse Gas Sources and Sinks in Canada
US population - EIA SEDS; Canada population - Statistics Canada
Gross Emissions - Consumption Basis

Sources:
EPA - State CO2 Emissions from fossil fuel combustion, 1990-2005
Environment Canada - National Inventory Report 1990-2005: Greenhouse Gas Sources and Sinks in Canada
Partner Emissions & Targets vs. 1990

**History:**
US - state greenhouse gas inventories
Canada - Environment Canada - National Inventory Report 1990-2005: Greenhouse Gas Sources and Sinks in Canada

**Projections:**
US - state GHG projections and climate action planning documents
Canada - linear trend extrapolation

**Targets:**
US - state climate action planning documents; Pew Center on Global Climate Change, http://www.pewclimate.org/states-regions
C-ROADS at COP-15

- President briefed by Science Advisor
- Scoreboard went viral
- Real-time analysis picked up by media, negotiators
- US State Dept used as common platform, picked up by other delegations

“This capability, had it been available to me when we negotiated Kyoto, would have yielded a different outcome.”

Tim Wirth, President, UN Foundation, former Senator
The Climate Scoreboard

Dr. Elizabeth Sawin
Andrew Jones
Stephanie McCauley

1 April 2010

www.climatescoreboard.org
Recent Results

Global CO$_2$e Emissions

- **Business as Usual**
  - Atmospheric CO$_2$: 965 ppm
  - Atmospheric CO$_2$e: 1410 ppm
  - Temp. Increase Over Preindustrial (90% C.I.): 4.8°C (2.9°-7.7°)
    - 8.7°F (5.2°-13.9°)

- **Confirmed Proposals**
  - Atmospheric CO$_2$: 770 ppm
  - Atmospheric CO$_2$e: 1015 ppm
  - Temp. Increase Over Preindustrial (90% C.I.): 3.9°C (2.3°-6.2°)
    - 7°F (4.2°-11.1°)

- **Potential Proposals**
  - Atmospheric CO$_2$: 585 ppm
  - Atmospheric CO$_2$e: 715 ppm
  - Temp. Increase Over Preindustrial (90% C.I.): 2.9°C (1.7°-4.6°)
    - 5.2°F (3.1°-8.3°)

- **Low Emissions Path**
  - Atmospheric CO$_2$: 470 ppm
  - Atmospheric CO$_2$e: 520 ppm
  - Temp. Increase Over Preindustrial (90% C.I.): 2°C (1.2°-3.1°)
    - 3.5°F (2.1°-5.7°)

Climate Scoreboard ©Sustainability Institute April 1, 2010 www.ClimateScoreboard.org
CO₂ in the Atmosphere

- Business as Usual
- Confirmed Proposals
- Potential Proposals
- Low Emissions Path

Parts per million

2000 2050 2100

01-Apr-10 Climate Scoreboard © Sustainability Institute www.ClimateScoreboard.org
For latest results or questions

www.ClimateScoreboard.org

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